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**Commission of Conservation
Canada**

COMMITTEE ON LANDS

**Fertilizers and Their Use
in Canada**

BY

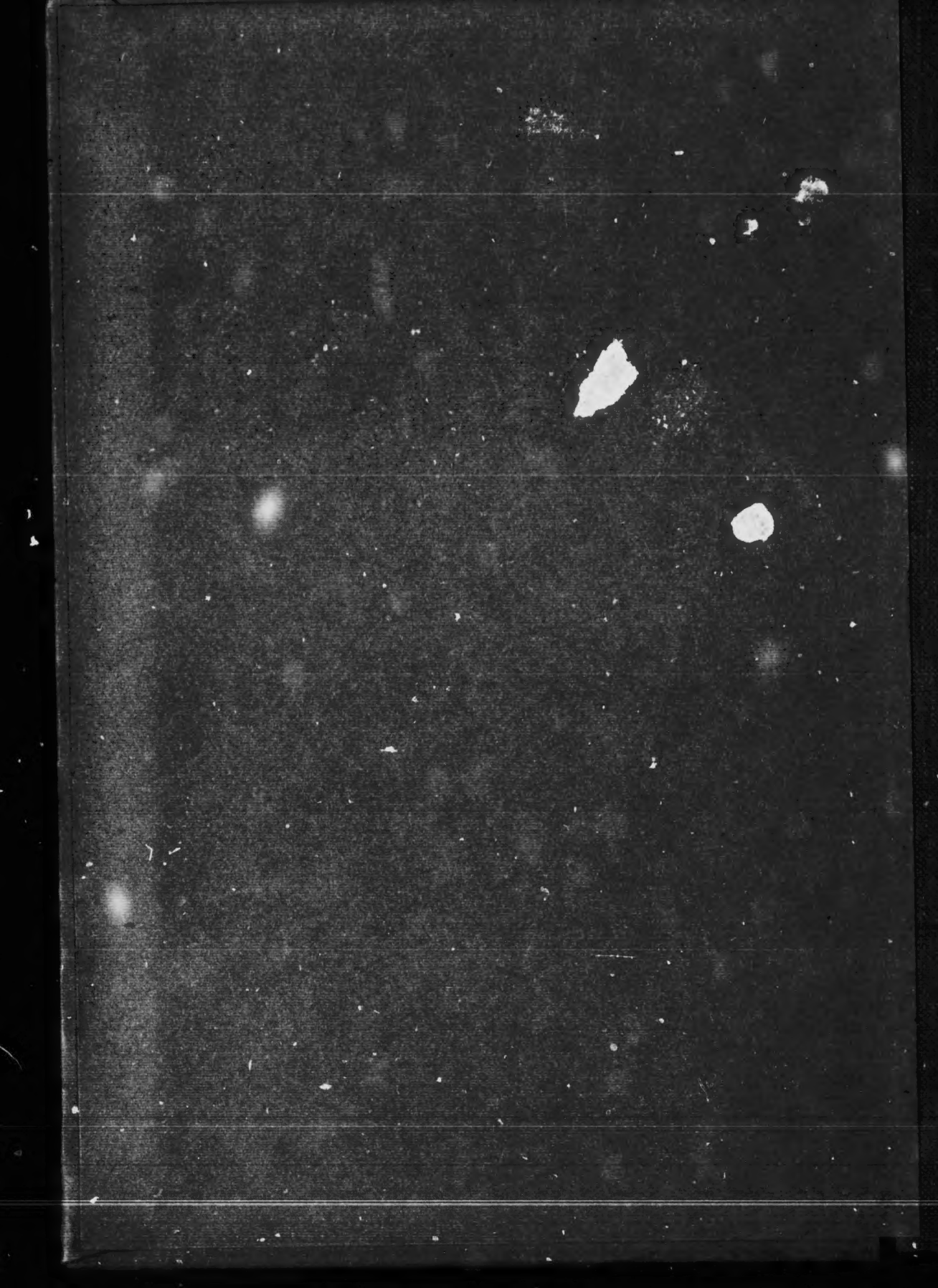
FRANK T. SHUTT M.A., D. Sc.

Dominion Chemist

Reprinted from the Eighth Annual Report of the
Commission of Conservation

1917

THE PENETRATED PRESS, LIMITED
MONTREAL



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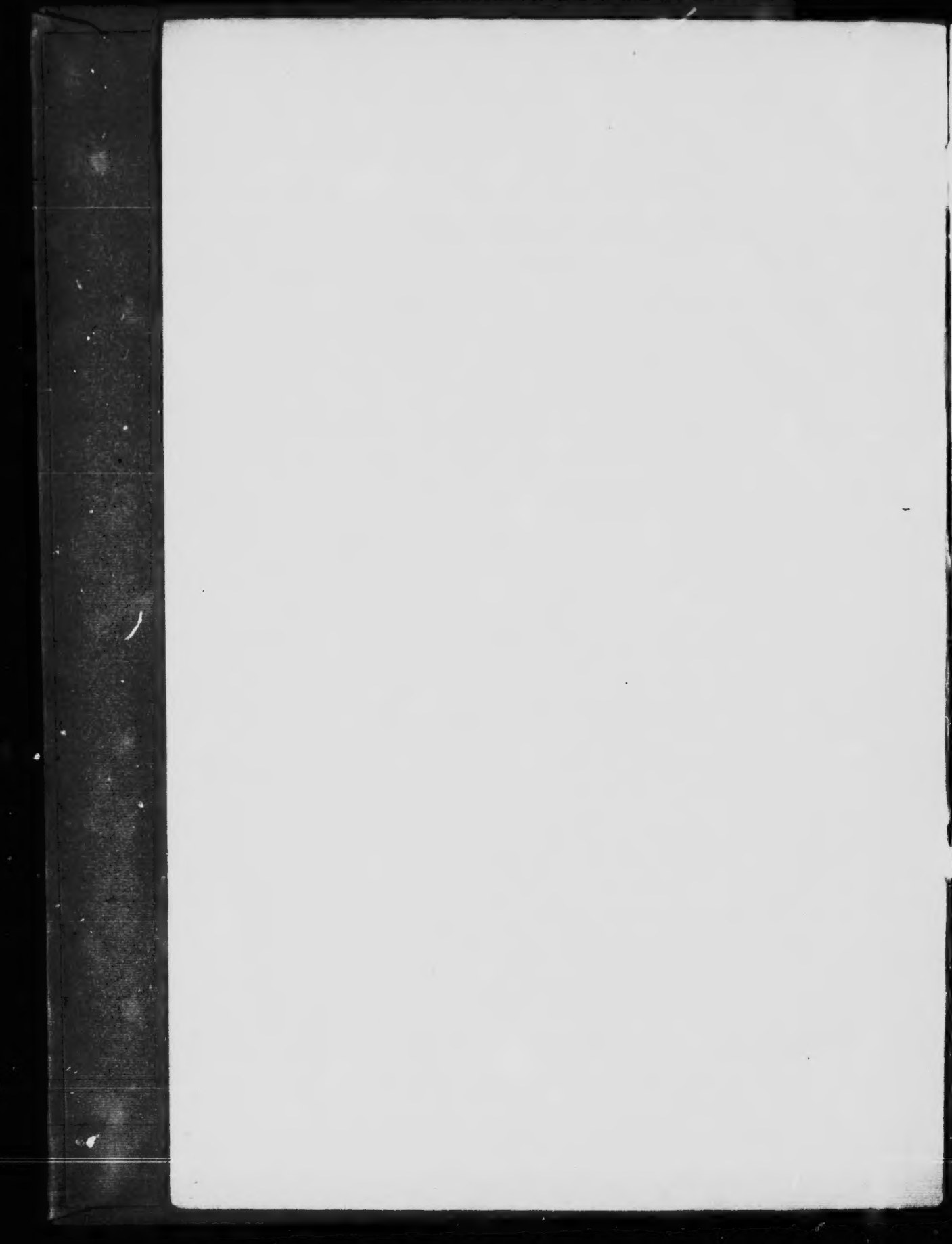
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THE request to take part in this morning's programme in the consideration of this important subject of fertilizers and their use in Canada, reached me at almost the eleventh hour, and this, together with the fact that we are busily engaged with matters arising out of war conditions has made it impossible for me to prepare a paper which might completely and satisfactorily set forth the investigational work that we have done and are doing in Canada under the direction of the Division of Chemistry of the Dominion Experimental Farms system. However, as such a paper would necessarily have been too long for presentation in the time allotted, I shall content myself with bringing before you, as concisely as possible, some of the more important conclusions we have tentatively reached.

Recognizing that employment of fertilizers in Canada to date has been limited, and that, to-day, their use is practically restricted to certain areas devoted to potatoes, sugar beets, tobacco, market garden, or other specialized "money" crops, and further, that our experiments, from which reliable conclusions could be drawn, have been carried on at a comparatively small number of points in the Dominion and over comparatively short periods of time, it should be distinctly understood that our conclusions are, more or less, tentative in character. We do not wish to be dogmatic as to the interpretation of the results obtained and we shall be extremely cautious in the matter of prophecies for the future.

Small as our use of fertilizers has been, that use is steadily, though certainly slowly, on the increase, and, doubtless, with the adoption of more intensive methods (which will follow as our country becomes more thickly settled) and with better, steadier markets for farm produce at home and abroad, this use will more and more increase. Indications are all in this direction, but it would not be wise to advocate, throughout Canada, the general and indiscriminate use of fertilizers on all soils and for all farm crops. While we are anxious that our yields should reach the highest possible profitable limit, there are no grounds for preaching the doctrine, as is the opinion of some, that this can be effected simply by the application of fertilizer.

**Fertilizers Are
Supplementary**

Fertilizers have a place in a rational system of farming; but farmers should first clearly understand what that place is, if our land is to improve rather than to deteriorate, and if financial loss, due to injudicious purchase of fertilizers, is to be avoided. We must first have sound education, the outcome of science with practice, on the principles involved in the up-keep of soil fertility, on the composition, value, care and application of farm manures, on the desirability of more live stock on our farms and the greater consumption on the farm of the land's produce; on the importance of rotations, and especially the value of clover and other legumes in the rotation for maintaining the humus and nitrogen of the soil, on the proper working of the land and the preparation of a good seed bed. When all these matters are correctly understood and practised, then, and not before, may we advocate the judicious employment of fertilizers with advantage, in general farming. Fertilizers are no panacea for the evils of poor farming—they cannot be depended on solely to give profitable yields, to leave the land richer for posterity than when first broken, or entered upon. That is what we ought to aim at, for our native fertile soils are a great and important national asset and inheritance. Our experience has shown that fertilizers cannot profitably be used as substitutes for manure, for the growing of clover, or for good soil management, but that their rôle is rather supplemental to all these rational means for the up-keep of soil fertility.

I make this statement for two reasons: First, there are, at the present time, those who are urging us to a large and practically universal, almost indiscriminate, use of fertilizers; and second, from our voluminous correspondence on the subject, it is evident that, for the most part, it is the man using poor farming methods who is clamoring for cheaper fertilizers, and who practically expects to conduct his farming profitably from their exclusive use. I feel assured we shall never see the time when fertilizers can be profitably used as a substitute for those means which science and practice alike have shown to be necessary for the economic up-keep and increase of soil fertility.

**Helping the
Farmers**

But there is a place for fertilizers in farming, and we are helping our farmers to find it. There are those of the old school still in the land, however, who have no faith in fertilizers, those who relegate them to the class of quack medicines, as frauds and fakes, and who say they act merely as a whip to a tired horse—as stimulants and not food. The number of these persons is happily decreasing. Again, there are others who, almost as ignorant of the principles of agriculture as

those just referred to, argue that if fertilizers are sources of available plant food, all that is necessary to increase our crop yields is to apply them generously. These persons are ignorant of the fact that there are limiting factors to crop growth other than the presence of available plant food. We may enumerate some of them. First, there is the nature and physical condition of the soil, its capacity for holding moisture (dependent upon its texture and its humus content), in other words, its power to withstand drought, also its degree of aeration, its drainage, etc.—all those qualities of a physical character which make for the easier development of the root system. Second, the character of the season, by which I mean the amount and distribution of rain, temperature, hours of sunshine, etc. So far as we can see today, seasonal conditions are the most potent of all determinative factors in crop yields in Canada, as probably, also, all over the world. And, lastly, there is the inherited capacity for growth and reproduction in the crop sown. All these, with some others, are limiting factors that cannot be overlooked; they are factors which may and do profoundly modify the effect of fertilizers. For instance, upon heavy, undrained clays, what chance is there that fertilizers can play their part in nourishing the crops? On the other hand, as plants can only absorb their soil food in the form of a solution, how can fertilizers feed the crop, if the light soils readily dry up with a few days drought, owing to lack of humus or want of surface cultivation? Or, again, if we are sowing a variety of oats, the prolificness of which is measured by 40 bushels per acre, can we make it yield 60 bushels by simply feeding it? Many of these limitations may be in some degree overcome through the application of the teaching of science—of chemistry, physics and biology, but they are not to be overcome simply by the application of fertilizers.

The Soils of Canada

Since no intelligent consideration of this subject is possible without some knowledge of the native and natural fertility of the soils which it is sought to improve by the application of fertilizers, a word or two must be said of Canadian soils in general. Time will not permit of more than a few generalizations, though the data we have amassed on this phase of the subject during the past twenty-five years are not only of great scientific interest but will be found to have a far-reaching importance in connection with the future of the agricultural industry of Canada.

As might be expected, there are within the domains of the Dominion, soils of many types and classes, ranging from the most fertile to be found anywhere in the world to those so poor and thin as to

be practically worthless for ordinary farming, and which should be reserved for forestry purposes.

Every province in the Dominion possesses tracts of land of considerable magnitude that compare favourably with the most productive of other countries. But, in respect to the size, number and relative fertility of these tracts, the provinces differ, and in this fact will, no doubt, be found one of the factors in determining what might be termed the provincial consumption of fertilizers. Other factors to this end will be density of rural population, character of farming, proximity of markets for concentrated products, etc. It is not simply a case of relative poverty of soil, as might be at first supposed, that determines fertilizer consumption.

As is well known, the provinces of Manitoba, Saskatchewan and Alberta contain the largest and most continuous areas of the richest soils. Many of these, as our analyses show, are veritable mines of plant food; for example, the alluvial prairie of the Red River valley, the uniform fertility of which it would be difficult to exaggerate.

Without discussing the relative agricultural values of the arable lands of our several provinces, the indications are that fertilizers will be found more particularly helpful in the Maritime Provinces, in Quebec and in British Columbia. This does not mean that profitable farming will not be possible in these provinces without fertilizers, but that they possess areas of cultivable land upon which these aids to fertility can be used profitably and to advantage when coupled with rational methods of soil management.

Climate and
Fertility

A cognate feature which is frequently overlooked, but which has a more or less direct bearing on the fertilizer question in Canada, is the influence of climate on fertility. It is realized by few that climatic conditions—rainfall, temperatures, etc.—exert a profound influence on the nature and composition of soils, both in their origin and in the power to conserve their fertility. These influences may tend to the accumulation or the dissipation of those elements or soil constituents which make for fertility. In this regard, save our coastal lands with excessive rainfall, which may keep the lighter soils poor in available plant food, our country is singularly blessed. We cannot now elaborate this question, but one instance may be cited that may serve as an illustration—one which undoubtedly influences in a beneficial way the fertility of our soils. The rigorous winter that prevails over the greater part of Canada locks up for several months—practically from harvest to seeding time—the soil's fertility. The plant food that has been converted into available forms during

the preceding summer and autumn and which is left over after the season's growth, is conserved for the crop of the succeeding year. The frost holds tight within its grasp plant food of untold value—especially the more valuable nitrates, so necessary for stimulating the growth of the young crop. In regions enjoying a more open winter, this soluble plant food would be lost by leaching. With all their drawbacks, our severe winters, with their almost continuous low temperatures, must be regarded, in their rôle as conservers of fertility, as an agricultural asset of no small value, one which must profoundly affect in a beneficial way our dependence upon purchased fertilizers for satisfactory yields.

CONCLUSIONS FROM EXPERIMENTS WITH FERTILIZER

We must now endeavour to present, in the most concise form possible, some of the more important conclusions reached by us in our fertilizer investigational work during the past twenty-five or thirty years. The amount of data we have to draw upon for these conclusions is very voluminous, but this fact does not, unfortunately, lessen the difficulty of the task. That only outstanding and apparently clearly established conclusions may be presented here, I shall eliminate all consideration of work which, for one reason or another, has not yet given concordant results, work which has not yet arrived at the stage for final deductions and work which, from faulty planning or carrying out, or owing to the misfortunes of the weather, has been, in our opinion, vitiated. As details of weights of fertilizers applied, crop yields, etc., consume much time in presentation and are difficult to follow with appreciation, we shall practically omit their statement and consideration.

The Prairie Provinces

Particular interest attaches to the question of fertilizers in the great grain-growing provinces of Canada—Manitoba, Saskatchewan and Alberta. We are very anxious to increase our north-western yields, especially in these days, when our wheat is needed to sustain the soldiers of our Empire in the great war we are waging for righteousness and justice. But we have no data which would justify us in saying that this could be profitably brought about by the application of fertilizers. For ten consecutive years—from 1900 to 1909—we carried on a series of fertilizer experiments on the Experimental Farms at Brandon, Man., and Indian Head, Sask. The series contained plots dressed with several forms of nitrogen, of phosphoric acid and potash, singly and in combinations of twos and threes. The results, taken one year with another, failed to indicate any material

increase in the yields of the fertilized over those of the unfertilized plots. Frequently the latter gave the larger crops, but it was seldom that the differences between the plots of the series exceeded the amount that might be attributed to experimental error. Certainly there was no consistent increase due to any fertilizer, and in no case was the increase sufficient to cover the cost of the fertilizer. These experiments, it must be noted, were conducted on excellent soil, of high quality, and wheat was the crop used.

For some years past we have carried on fertilizer experiments at a number of Experimental Stations in northern Saskatchewan and Alberta. So far these have failed to indicate any specific want of plant food in the soil; the results were irregular, and the increases on the dressed plots were not of that magnitude to warrant definite conclusions as to the virtue of the several fertilizing constituents employed or the expenditure for their purchase and application. On the whole, therefore, our results have been of a negative character.

With respect to the future, my opinion is that the time may come when phosphates will be found useful. My reason for this conclusion is that, of the three essential elements, these soils are least rich in phosphoric acid, and that the extensive growing of grain crops will tend to diminish the available store of this element that is more or less available for crop use. Moreover, phosphates may be found of value in inducing an earlier maturity of the crop—a matter of much importance in districts where early autumnal frost endangers the ripening wheat crop. The introduction of mixed farming, with the adoption of rotations which will serve to maintain the humus content of the soil, should be sufficient, in my opinion, to obviate any necessity for relying generally on fertilizers for the up-keep of the fertility of these soils. At the present time, I feel assured that the determinative factors in crop production in these regions are the seasonal conditions, more especially as to the amount and distribution of the spring and early summer rains, and the thoroughness with which the land is prepared, which latter, of course, is intimately connected with the vital question of the conservation of soil moisture. If our northwestern lands are not to be allowed to deteriorate, mixed farming must be more and more introduced, and it is, above all, imperative in the highest degree that the humus content be constantly replenished, not only to keep fibre in the soil that will prevent loss from "blowing", but to maintain their present high capacity for holding moisture.

British
Columbia

With regard to British Columbia, the results that we can review for the purpose of this paper have been chiefly obtained at the Experimental Farm at Agassiz, 80 miles from the coast, the soil being of a poor, gravelly or sandy nature. Many of these experiments have been in course for six and seven years. Potatoes and mangels are the two crops that have been chiefly used, though there is one extensive series under a four-year rotation, including one year of oats. The results have been somewhat irregular, varying with the character of the season, but emphatic evidence has been obtained as to the effectiveness of fertilizer applications in conjunction with manure, more especially on the mangel crop. The most profitable results have been obtained from the use of a "complete" fertilizer, that is, one supplying nitrogen, phosphoric acid and potash. In the larger number of instances the fertilizers yielded a good profit. The more profitable formulæ contained nitrate of soda, 100 to 160 pounds; superphosphate, 350 to 400 pounds; and muriate of potash, 100 to 200 pounds, these amounts being per acre. The evidence so far is satisfactory, in pointing to a profitable use of fertilizers on hoed crops, provided that use is judicious and rational.

We are unable, at the present time, to say what may be the value of fertilizers in the interior of British Columbia—the so-called "dry belt", in which irrigation is practised—but experimental work is in progress there which will, in the course of a few years, furnish useful data. Arguing from the nature of the soils and the climatic conditions that prevail there, however, it is not likely that the response will be of the same large order of merit that we have observed on the coast and on Vancouver Island.

Central
Experimental
Farm

Investigational work with fertilizers was instituted on the Central Experimental Farm, Ottawa, in 1888, and is still in progress. As the data are very voluminous, time will not permit a review of all the numerous lines undertaken. It must suffice here to indicate some of the more important or outstanding of the results obtained. The soil is a light sandy loam, of medium quality, and, in the larger number of the experiments, especially during the latter years, a three-year or four-year rotation has been followed. Great difficulty has been experienced at this station from lack of uniformity in the land under experiment; indeed, this is a difficulty we have been forced to contend with at a considerable number of our stations, though all possible care was taken at the outset to select a suitable area for the work. It should be added that the work at Ottawa has included the com-

parison of fresh with rotted manure, the manurial value of clover as compared with farm manures and fertilizers, and the testing out of a number of materials not generally recognized as fertilizers.

Perhaps one of the most remarkable results obtained has been the discovery that, as far as ordinary farm crops are concerned, fresh and rotted manure, applied at the same rate, have given practically equal yields. The explanation for this is not easy to find, since rotted manure, weight for weight, is very considerably richer in plant food than fresh manure. It probably lies in the better inoculation of the soil with desirable micro-organisms for the conversion of soil plant food into assimilable forms by the fresh manure and the greater warmth set up by its fermentation in the soil affecting beneficially the crop in its early stages. But, be this as it may, we have the practical deduction that there is no concomitant gain from the use of rotted manure, in the ordinary farm rotation, for the labour involved in rotting it and the large losses in organic matter and plant food that inevitably accompany the operation. The quicker the farmer can get the manure into the land or onto the land the better, for it is never worth more than when first produced.

Manurial
Value of
Clover

The manurial value of clover need not be dwelt upon at any length. Our work in this connection is fairly well known throughout the Dominion.

It has been of an exhaustive nature and has yielded most satisfactory results—indeed, it would be difficult to overestimate its value to Canadian agriculture. Chemically, physically and biologically the growth and turning under of clover improves the soil, and we have been enabled to demonstrate over and over again that a crop of clover in the rotation has a manurial effect equal to an application of farm manure of ten to fifteen tons per acre.

As regards fertilizers, our work has not shown any marked specific deficiency in our soils, though the response to nitrogenous fertilizers is perhaps the most pronounced. Almost invariably, the increases have been larger and more profitable from a complete fertilizer than from an application of any one or two of the fertilizer constituents.

While, in general farming, fertility cannot be economically maintained and profitable yields obtained by the exclusive use of fertilizers, *our experiments have shown that fertilizers may be used to good advantage in conjunction with farm manures.* This deduction is probably true for the greater number of our agricultural areas in Eastern Canada and on the western coast. When manure is scarce, or has to be purchased at a high price, then it will assuredly be found desirable to purchase fertilizers, not to take the place of

the manure, but to supplement its scanty use. If we cannot apply manure at the rate of fifteen tons per acre, our experiments indicate that we can use half that quantity and dress with judicious amounts of fertilizer without materially affecting the results. The probability is that, today, on the average farm the net profits per acre would be much the same under either system of procedure. With cheaper fertilizers, or with a higher rating for farm manures, than we have today, there would probably be a more profitable showing from the manure and fertilizer mixture than from the exclusive use of manure.

No profitable response has been obtained from the direct application to the soil of finely ground untreated mineral phosphate (apatite), though special experiments, in which this material was mixed with actively fermenting manure, the whole being left for several months, showed that small amounts, practically traces, of the insoluble phosphate were converted by this means into soluble forms.

Basic slag has proven the most useful phosphatic fertilizer on sour soils or heavy clay loams, on soils naturally deficient in lime, and on peats and mucks, while on the lighter soils rich in lime, superphosphate has given the quickest returns, especially for turnips and the cereals.

On land in fair condition a top dressing of nitrate of soda, applied in the early weeks of growth, has been found beneficial to grass, more particularly when intended for hay.

No potassic fertilizer has proved more valuable than good hardwood ashes. Of the three essentials, potash appears to be the least needed, but, on many light loams, it has given a good return, for encouraging the growth of clover and for vegetables and leafy crops generally. Muck and peaty soils frequently stand in need of this element. On heavy clay soils potash is not, as a rule, remunerative.

Fertilizers in Eastern Canada

By far the larger amount of our investigational work with fertilizers has been carried on in recent years in the Maritime Provinces, especially New Brunswick and Nova Scotia, and our results merit a more careful consideration than we can now give to them. However, it is satisfactory to note that the deductions made from the work at Ottawa hold good in the main for eastern Canada. There is, however, apparently a larger and more lucrative field for fertilizers in the east, not simply as we might suspect, from poorer soils, but from the fact that the crops upon which they are used are more particularly "money" crops, such as potatoes, apples, etc., from which a larger money return can be expected. If the maximum gross returns per acre

are in the neighbourhood of \$150 rather than \$50, it is obvious that the prospect for a remunerative response from the fertilizer is greatly enhanced.

The importance of manure and clover in maintaining the humus content of the soils has been strongly emphasized in all our work in Quebec and the Maritime Provinces. Perhaps I might say that the need for these means of soil improvement is greater, speaking generally, than in Ontario. But, be that as it may, we have almost invariably obtained the more lucrative responses from fertilizers on soils enriched by manure and under a rotation in which clover is a member. On potatoes and market garden crops generally, an application of manure at the rate of 15 tons per acre, with a moderate application, say, of a well-balanced fertilizer, has given more profitable returns than either 30 tons of manure or a dressing of 800 to 1,000 pounds of a similar fertilizer without manure. These results have been confirmed at many points and in different seasons. The largest profits obtained have been from this combination and not from very large applications—1,000 pounds or over—of fertilizer, no matter how well blended to suit the soil and crop requirements. This, translated, means what we have already stated, that the rôle of fertilizers, if they are to be used profitably, is as a supplement to, and not as a substitute for, manure.

**Results of
Experiments**

The majority of our experiments have shown that excessively large dressings of fertilizer have not given net profits per acre of the same magnitude as medium applications, say, 400 to 600 pounds, and we counsel our farmers to ascertain, each for himself, by experimentation and the employment of an undressed area or check plot, what the limits of profitable application are for his land. There is, unfortunately, in the present state of our knowledge, no laboratory method by which we can do this for him.

Again, we found that the greater return—the larger profit—came from using a complete fertilizer, that is, one containing nitrogen, phosphoric acid and potash, and this points to the conclusion that the function of fertilizers is to raise the small proportion of available plant food in the soil rather than to increase materially its total plant food content.

Summarizing

Our experiments, in general, have gone far towards establishing that a judicious and rational use of fertilizers may be depended on to yield a profit, that the *exclusive* use of fertilizers will neither keep up the fertility of the soil nor yield profitable returns, and that it is on soils of medium

rather than poor quality that a lucrative response from their employment is to be expected, and, lastly, that it is on the "money" crops that we shall find the application most profitable.

Had time permitted, we might have informed you of the valuable results we have obtained with liming and the use of finely ground limestone, especially in Eastern Canada, of our experiments with fish-waste manures and with dried ground seaweed; of the many naturally-occurring materials of manurial value in our country that might be more generally used, and many other phases of this great and important subject of maintaining and increasing soil fertility. In this address I have endeavoured to tell you, briefly, of our extensive experimental work with commercial fertilizers and its results, and, further, what is perhaps more important, our teachings and the position we have taken based on these results. The advice that is constantly and increasingly asked of us by our farmers to guide them in their use of fertilizers finds its foundation largely in the deductions brought forward today, and we trust we have in some small measure made clear the general lines upon which that advice is given.